Portable Particulate Matter (PM) Sensor for Air Pollution Monitoring

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Abstract

Atomospheric particulate matter (PM) are tiny airborne pollutants floating in the air. They come from construction materials, dust, smoking, cooking, automobile exhaust, charcoal power plant, etc. Particulate matter pollutants are potential threat to human health. Particulate matters with diameter of 2.5µm or less are called PM2.5 and they are especially harmful for human respiratory system. They can penetrate into deeper part of lungs and human body does not have a mechanism to repel them out. Long term exposure to high concentration of PM2.5 leads to mesothelioma, lung cancer, bronchitis, heart attacks and many other diseases. Air pollution is also becoming a serious problem in many developing countries due to their increased activity in developing the economy. Traditional PM detectors are heavy, bulky and expensive. As people are becoming more and more aware of the health threat of air pollutants, a low-cost and portable PM sensor is in great demand. In this poster, a particulate sensor based on MEMS (Microelectromechanical Systems) technology is proposed. Due to MEMS technology, it has the advantages of small size, low weight, low cost and high sensitivity. People can easily carry it to monitor the air quality anywhere they go. This can protect users from potential exposure to the polluted air in-door or during travel. The PM sensor was designed and its function is verified with COMSOL simulation.

Introduction

Particulate matter (PM) is an extensive air pollutant, consisting of small solid particles, liquid particles or both suspended in the air. The level of particles separates in size, the diameter of less than 10um is PM10 (the inhalable particulate matter) and less than 2.5µm is PM2.5 (fine PM). In this Figure 1[3], the human hair is about 70 micron meter, it compare with particulate matter is 10 micron meter in diameter (PM_{10}). PM_{10} is just one fifth. $PM_{2.5}$ is less than PM_{10} and is too small to invisible.

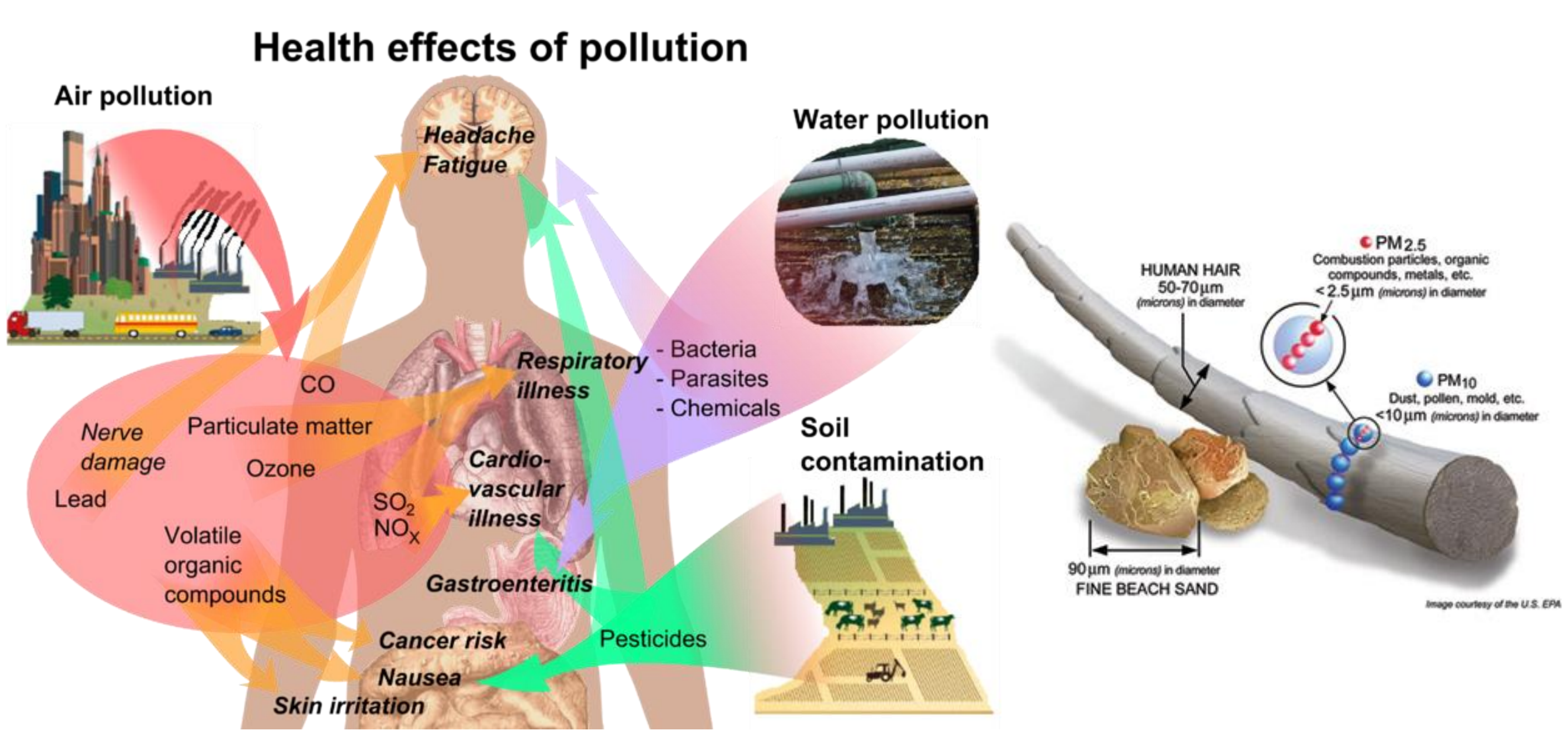

Figure 1. Health threat of PM and size comparison of hair, $PM_{2.5}$, PM_{10}

Figure 2. Air pollution caused by PM particulate matter

PM Detector Design

In this project work, a COMGOL model device model has been shown on Figure 3. The left port is the PM filter; the torus is simulated as fan port; the right port is the electric field and the block dots are the particulate matters (PM). This device first port start to work is the fan that will force the air to through the inlet. Inlet is reticular filter and the filter goes to stop particulate matter (>2.5 micro in diameter). If there is a cutting before the filter or changing the filter is with a cutting in unit, the air sample will be more accurate. After the particulate matter will arrive corona region and every particulate matter gets a electric charge (suppose every PM just average get one electric charge). The particulate matters continue moving and the go to collecting field. The electric charges which are moving with PM less 2.5 micro in diameter until change electric field when they arrived in the area. The changing value of voltage can be transfer to a number show AQI. In the measurement of PM2.5, air sample must be chosen. The inlet of the device has a given selection function because just the particulate matters equal or less2.5 micro in diameter have actual value in the detection. The COMSOL model has been shown on Figure 4.

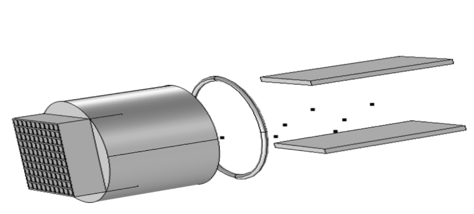

Figure 3. A summary monitor structure 3D model.

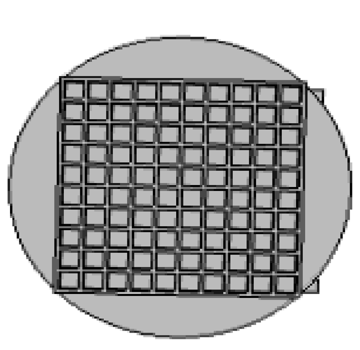

Figure 4. The inlet view of monitor

Results

An exact form of the inlet through efficiency curve for different particulate size the impact can remove the large PM without PM less 2.5 micron in diameter, other's effects are generally smaller. Figure 5, show a size selection efficiency curve for PM2.5.

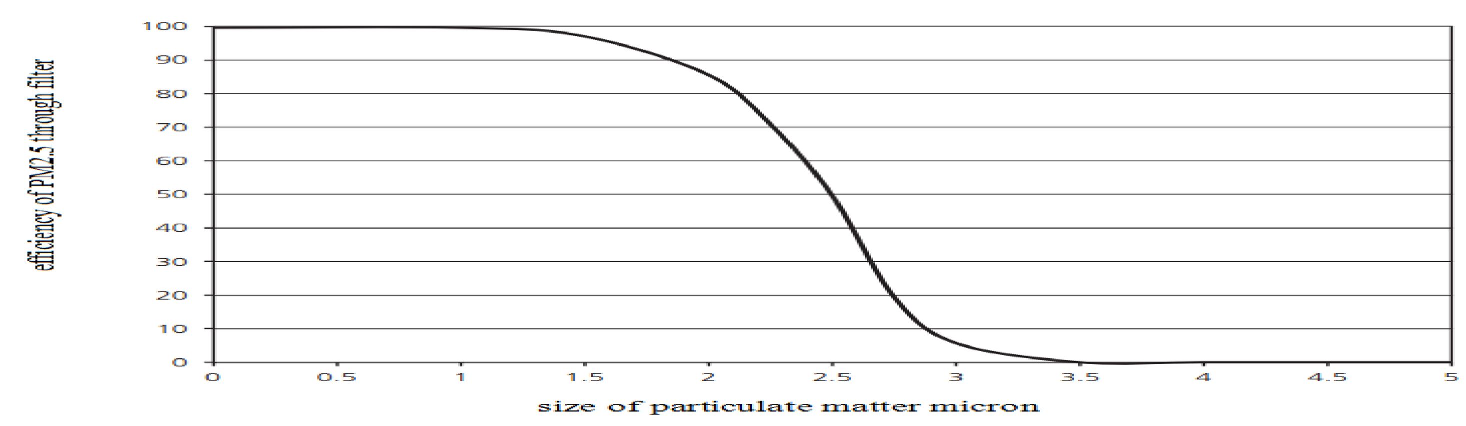

Figure 5. Illustrates an indicative size- selection curve for PM2.5

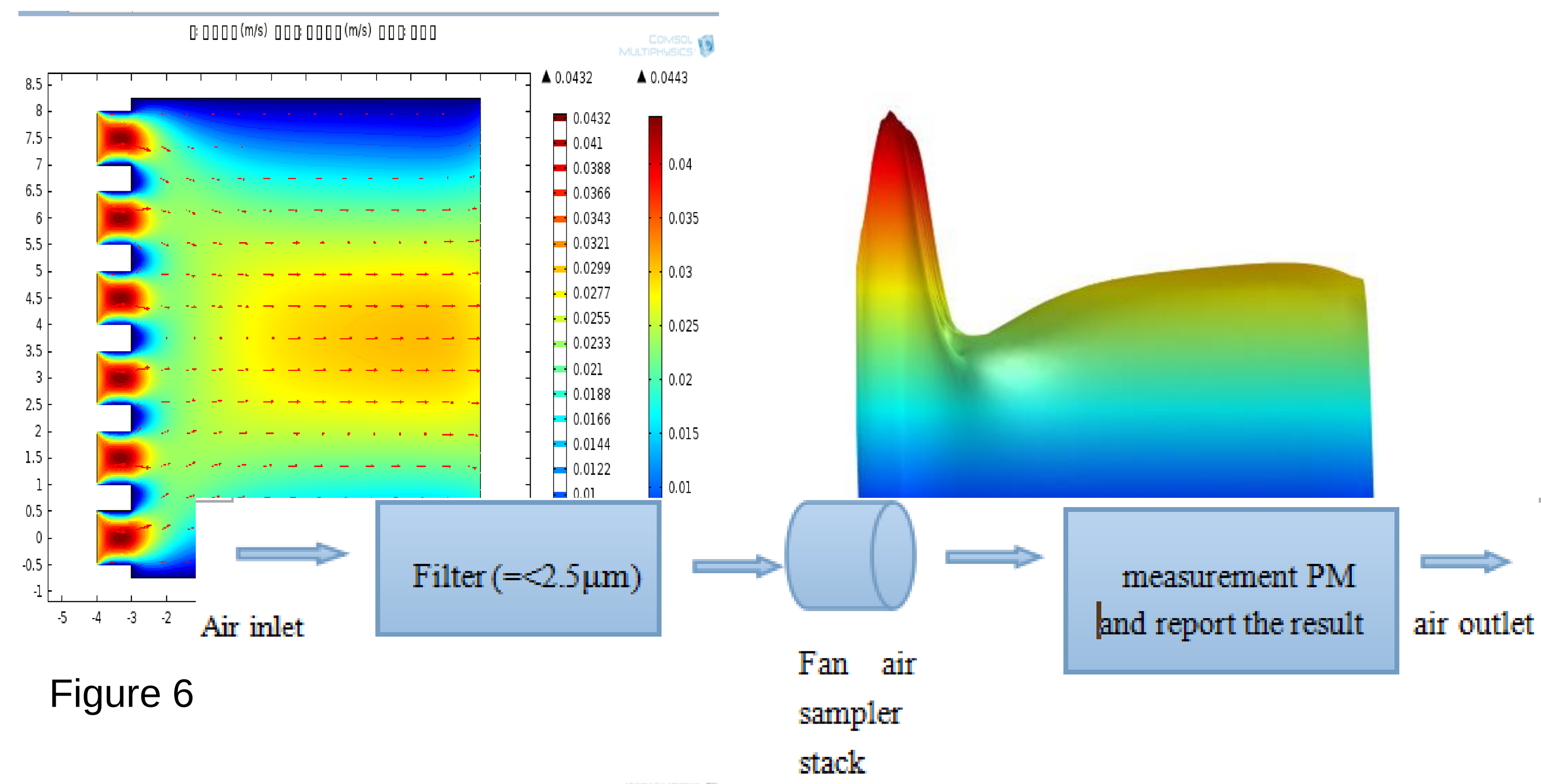

Figure 6

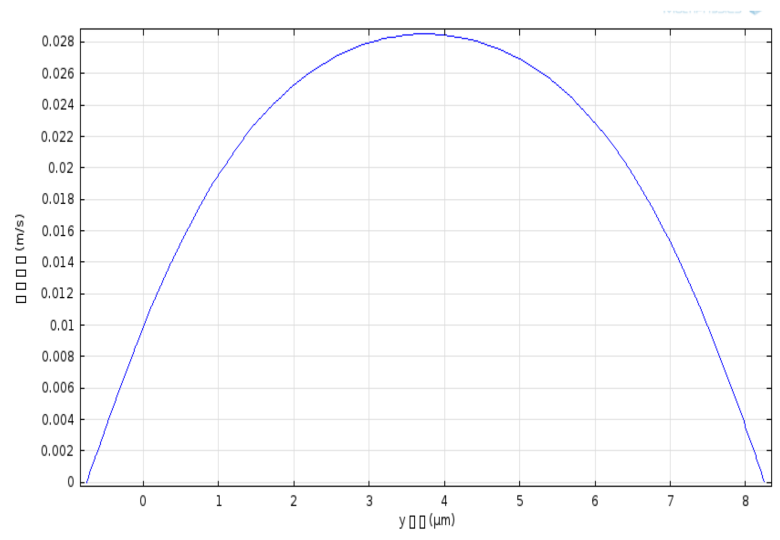

Figure 8. Speed of intersecting surface in channel

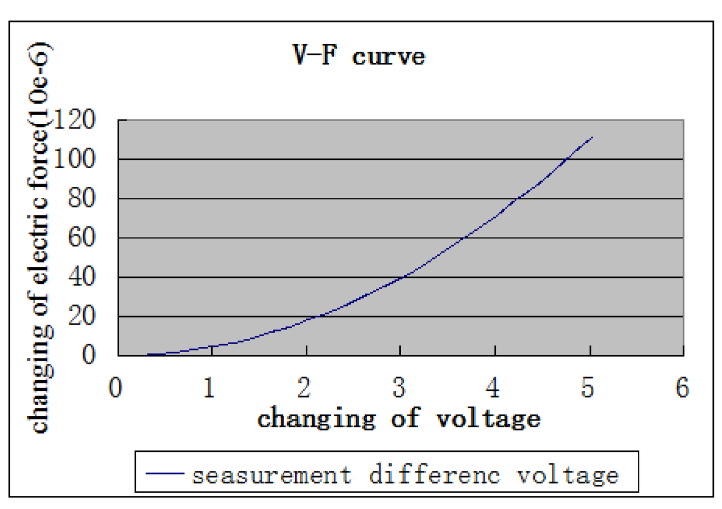

Figure 9. Voltage-Electric force curve

Assume ε_1 is metal oxide 15, E=1 v/m. The relation between particles in diameter and the number of particle .the number of particle is integer. After the filter just size less than or equal to 2.5 in diameter, so most of the particle get 0~3 charges. Figure 10 has been shown.

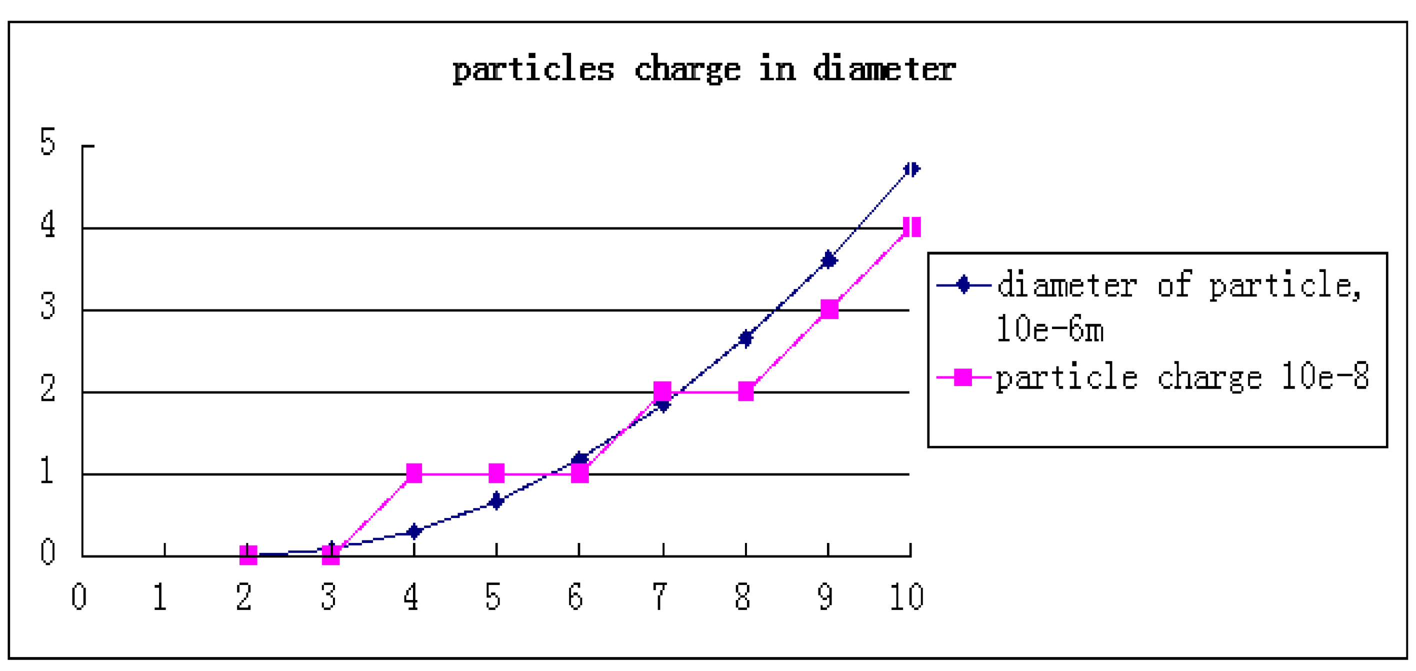

Figure 10. Particles charge in diameter

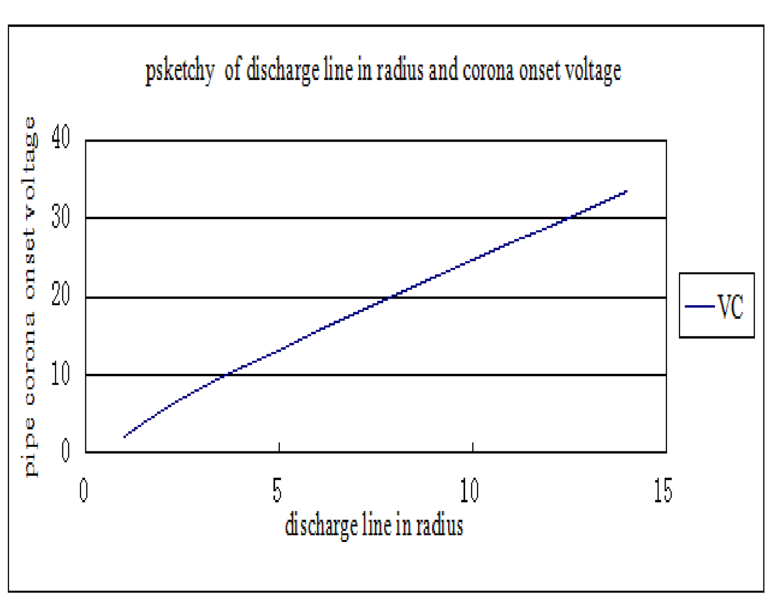

Figure 11. Simple relation curve, the radius and corona onset voltage

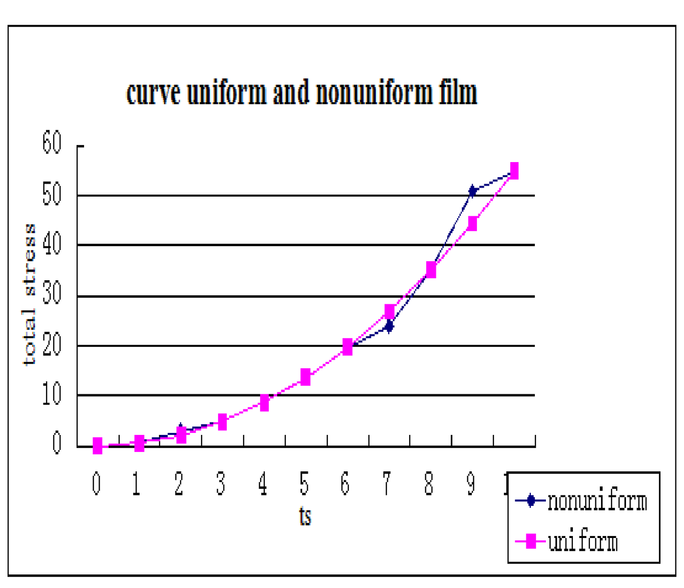

Figure 12. Comparing the different curves

For our work, nonuniform film will effect the parallel plates create a uniform electric field. So after finishing the plating metal film on structure(SiO, Si_xN_y). In the plating metal technology there are other methods to fix out plating problems.

Conclusion and Future Work

For our work, nonuniform film will effect the parallel plates create a uniform electric field. So after finishing the plating metal film on structure(SiO, Si_xN_y). In the plating metal technology there are other methods to fix out plating problems. In future work, small size but a great functions MEMS devices can be found. Solving the power problem is so essential. Raising the accuracy of measurement is one of future work for this design. This kind of small size device can be used in personal with low price or constituted with more smart or multi-function devices.